DEPARTMENT OF THE NAVY
NAVY EXPERIMENTAL DIVING UNIT
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PANAMA CITY, FLORIDA 32407-7015

IN REPLY REFER TO:

NAVSEA TA89-063

NAVY EXPERIMENTAL DIVING UNIT

TECHNICAL REPORT NO. 8-94

COMMERCIALLY AVAILABLE SCUBAPRO BUOYANCY COMPENSATOR

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APRIL 1994

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UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE

EPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION Unclassified	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT *DISTRIBUTION STATEMENT A: Approved for public release; distribution is unlimited*
2b. DECLASSIFICATION/DOWNGRADING AUTHORITY	
4. PERFORMING ORGANIZATION REPORT NUMBER(S) NEDU Report No. 8-94	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZ. Navy Experimental Diving Unit 6b. OFFICE SYMBOL (If Applicable) 03E1	7a. NAME OF MONITORING ORGANIZATION
6c. ADDRESS (City, State, and ZIP Code) 321 Bullfinch Road, Panama City, FL 32407-7015	7b. ADDRESS (City, State, and Zip Code)
8a. NAME OF FUNDING SPONSORING ORGANIZATION Naval Sea Systems Command 8b. OFFICE SYMBOL (If Applicable) 00C	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (City, State, and ZIP Code) 2531 Jefferson Davis Highway, Arlington, VA 22242-5160	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. / PROJECT NO. / TASK NO. 89-063 / WORK UNIT ACCESSION NO.
11. TITLE (Include Security Classification) (U) Commercially Available SCUBAPRO Buoyancy Compensator	
12. PERSONAL AUTHOR(S) ENC(DV/SW) J. A. Noe	
13a. TYPE OF REPORT Test Report 13b. TIME COVERED FROM JUL 92 TO APR 94	14. DATE OF REPORT (Year, Month, Day) APRIL 1994 15. PAGE COUNT 22
16. SUPPLEMENTARY NOTATION	

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	Buoyancy Compensator, Life Preserver, Authorized for Navy Use (ANU) list, Lift Capacity

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

Evaluations were conducted on the SCUBAPRO Military Classic Black Buoyancy Compensator to determine if it was capable of meeting performance standards for Navy use. Lift capacity evaluations were conducted in the Ocean Simulation Facility (OSF) at 18.2, 39.7, and 57.6 msw (60, 130, and 190 fsw) to determine maximum lift capacity using the power inflator and the CO_2 actuator assembly. Manned evaluations were also conducted to determine the floating attitude of an unconscious diver using this buoyancy compensator. Additionally, manned evaluations were conducted to gather human factors data regarding fit and function. All testing conducted determined that this buoyancy compensator was capable of meeting the requirements for acceptance by the US Navy.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT	21. ABSTRACT SECURITY CLASSIFICATION
[ ] UNCLASSIFIED/UNLIMITED [X] SAME AS RPT. [ ] DTIC USERS	Unclassified

22a. NAME OF RESPONSIBLE INDIVIDUAL	22b. TELEPHONE (Include Area Code)	22c. OFFICE SYMBOL
NEDU Librarian	904-230-3100	

DD Form 1473

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE

GLOSSARY

ANU	Authorized for Navy Use List (NAVSEAINST 10560.2 series)
BC	Buoyancy Compensator
fsw	Feet of Seawater
msw	Meters of Sea Water
NAVSEA	Naval Sea Systems Command
NEDU	Navy Experimental Diving Unit
OSF	Ocean Simulation Facility
psi	Pounds per Square Inch
SCUBA	Self Contained Underwater Breathing Apparatus

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ILLUSTRATIONS

INTRODUCTION

The requirement for a life vest or buoyancy compensator for use with open circuit SCUBA, with the ability to perform to a depth of 58 msw (190 fsw), has evolved from changes in diver mission profiles and concern for diver safety in the FLEET DIVER community.

To achieve this end, NEDU was tasked[1] to test and evaluate production models of commercially available life preservers and buoyancy compensators to determine which ones meet the US Navy's demanding operational requirements.

SCUBAPRO, Rancho Dominguez, Ca., provided the Military Classic Black Stabilizing Jacket for evaluations. This buoyancy compensator may be configured for use with either a single or double 2.26 m^3 (80 ft^3) SCUBA cylinder. Additionally, the buoyancy compensator may be fitted with a single or double twin 38 gram CO_2 cartridge actuator assembly.

It is important to note that, in US Navy terms, a buoyancy compensator is defined as a buoyancy control device incorporating oral inflation, emergency inflation by CO_2 cartridges, and inflation by an L.P. air supply. This air supply may be either from the diver's first stage regulator, or an independent pony bottle. A life vest is defined as a horsecollar style vest which has CO_2 cartridge and oral inflation capabilities only.

UNMANNED EVALUATION

METHODS

Unmanned evaluation of the candidate buoyancy compensator measured lift capacity at specific test depths[2]. Lift capacities were measured using both the CO_2 actuator and the power inflator. Testing was conducted in the Ocean Simulation Facility (OSF). Water temperature was maintained at ambient, approximately 21°C (70°F).

A calibrated spring scale was attached to the grating in the Ocean Simulation Facility (OSF) and the candidate buoyancy compensator was attached to the spring scale. The OSF was then pressurized incrementally to the test depths of 18.2, 39.7, and 57.6 msw (60, 130, and 190 fsw). At each test depth, the buoyancy compensator was inflated using the CO_2 actuator. The lift capacity was then measured and documented. At the 39.7 msw (130 fsw) test depth, the buoyancy compensator was tested using the single twin CO_2 cartridge and the double twin CO_2 cartridge actuator assemblies. At the 57.6 msw (190 fsw) test depth, only the double twin CO_2 cartridge actuator assembly was used. The buoyancy compensator was then deflated and re-inflated using the power inflator until the overpressure relief valve

vented. Once again, lift capacity was then measured and documented. The candidate buoyancy compensator was also checked for leaks at each test depth.

RESULTS

Figure 1 contains the results of testing conducted at 18.2 msw (60 fsw). The buoyancy compensator provided 14 pounds of positive lift using the CO_2 actuator, while providing 50 pounds of positive lift using the power inflator.

Figure 2 contains test results obtained at 39.4 msw (130 fsw). Using the single twin cartridge assembly provided 12 pounds of positive lift, while the double twin cartridge assembly provided 20 pounds of positive lift. The power inflator again provided 50 pounds of positive lift.

Figure 3 contains test results at 57.6 msw (190 fsw). The double twin cartridge assembly provided 18 pounds of positive lift, and the power inflator provided 50 pounds of positive lift.

It is important to note that although this buoyancy compensator meets the minimum lift requirement[4] using the single twin CO_2 actuator at 39.7 msw (130 fsw), the addition of the double twin actuator assembly greatly enhances the lift capabilities.

MANNED EVALUATION

METHODS

Manned evaluations[3] were conducted in two phases. In phase one, human factors evaluations were conducted, where diver subjects subjectively rated candidate buoyancy compensator performance, as well as fit and function during open sea dives to a maximum depth of 39.7 msw (130 fsw).

Phase two of the manned evaluations consisted of surface floating attitude testing conducted in the test pool. For this phase of testing, two bottom positions were chosen, prone and head down vertical, to represent the normal position of an unconscious diver and the worst case condition to attain a face-up attitude on the surface. Each diver subject wore a weight belt 20 pounds heavier than normally required. After the diver subject assumed a bottom position, the buoyancy compensator was inflated to achieve neutral buoyancy, and the weight belt was ditched. Diver subjects were completely limp and remained that way until the surface floating attitude was recorded by the topside observer. A total of 100 trials, 50 prone and 50 head down vertical, using a single SCUBA cylinder, and 100 trials, 50 prone and 50 head down vertical, using a double 2.26 m^3 (80 ft^3) SCUBA cylinder configuration were conducted.

All diver subjects were military divers with between 2 to 24 years of SCUBA diving experience and were highly familiar with the operation and use of SCUBA equipment.

HUMAN FACTORS EVALUATION

Diver subjects used the Human Factors Questionnaire (Appendix A), to evaluate fit and function subjectively as well as buoyancy compensator performance.

All ratings were on a 1-6 scale, with 1 being "extremely poor" and 6 being "excellent."

A total of sixteen divers, nine using a single and seven using a double 2.26 m^3 (80 ft^3) SCUBA cylinder configuration, completed questionnaires following each dive to evaluate the candidate buoyancy compensator.

RESULTS

Figure 4 contains the ratings for Overall Comfort. All nine divers using the single SCUBA cylinder rated this parameter as *acceptable* or better. Of the seven divers using the double SCUBA cylinder configuration, one diver rated this parameter as *not quite adequate*, with the remaining divers rating it as *acceptable* or better.

Ratings for Mobility are contained in Figure 5. All divers in both configurations rated this parameter as *acceptable* or better.

Donning and Doffing of the buoyancy compensator ratings are contained in Figure 6. All divers in the single SCUBA cylinder rated this as *acceptable* or better. One diver in the double SCUBA cylinder configuration rated this as *poor*, while the remaining divers rated it as *acceptable* or better.

Figure 7 contains the ratings for Attaining Neutral Buoyancy. All divers in both configurations rated this as *acceptable* or better.

Figure 8 contains the ratings for Location of Controls. All divers in the single configuration rated this as *acceptable* or better. One diver in the double configuration rated this as *not quite adequate*, with the remaining divers rating it as *acceptable* or better.

Ease of Operation ratings are contained in Figure 9. All divers in both configurations rated this as *acceptable* or better.

The Overall Rating for the candidate buoyancy compensator is contained in Figure 10. All divers in both configurations rated this parameter as *acceptable* or better.

For the surface floating attitude portion of the testing, of the 100 trials conducted using the single SCUBA cylinder configuration, diver subjects surfaced, and floated, face up 100 out of 100 times. In the double SCUBA cylinder configuration, diver subjects surfaced, and floated, face up 95 out of 100 times. Of the five times the diver subject was rolled over onto his face, it was found that due to the diver subject's small stature, the buoyancy compensator did not fit correctly when configured with the double SCUBA cylinders, thus allowing the cylinders to shift and roll the diver subject over.

CONCLUSIONS/RECOMMENDATIONS

Based on the results obtained during unmanned and manned evaluations of the SCUBAPRO Military Classic Black Stabilizing Jacket, NEDU recommends that this buoyancy compensator be **approved** for addition to the ANU List.

Additionally, for dives deeper than 27.4 msw (90 fsw), recommend the buoyancy compensator be configured with the double twin CO_2 actuator assembly.

REFERENCES

1. NAVSEA Task 89-063, *Commercial Buoyancy Compensator and Life Vest Test and Evaluation*.

2. *Evaluation of Commercial SCUBA Regulators OSF Bounce Dive Series to 190 FSW (Manned)*, NEDU Test Plan 92-44 (Limited Distribution), Navy Experimental Diving Unit, November 1992.

3. *Procedure for the Manned Evaluation of Commercially Available Buoyancy Compensators*, NEDU Test Plan 91-32 (Limited Distribution), Navy Experimental Diving Unit, August 1991.

4. NAVSEA Letter 3150 OOC32A SER OOC32/3265, 21 Jul 89.

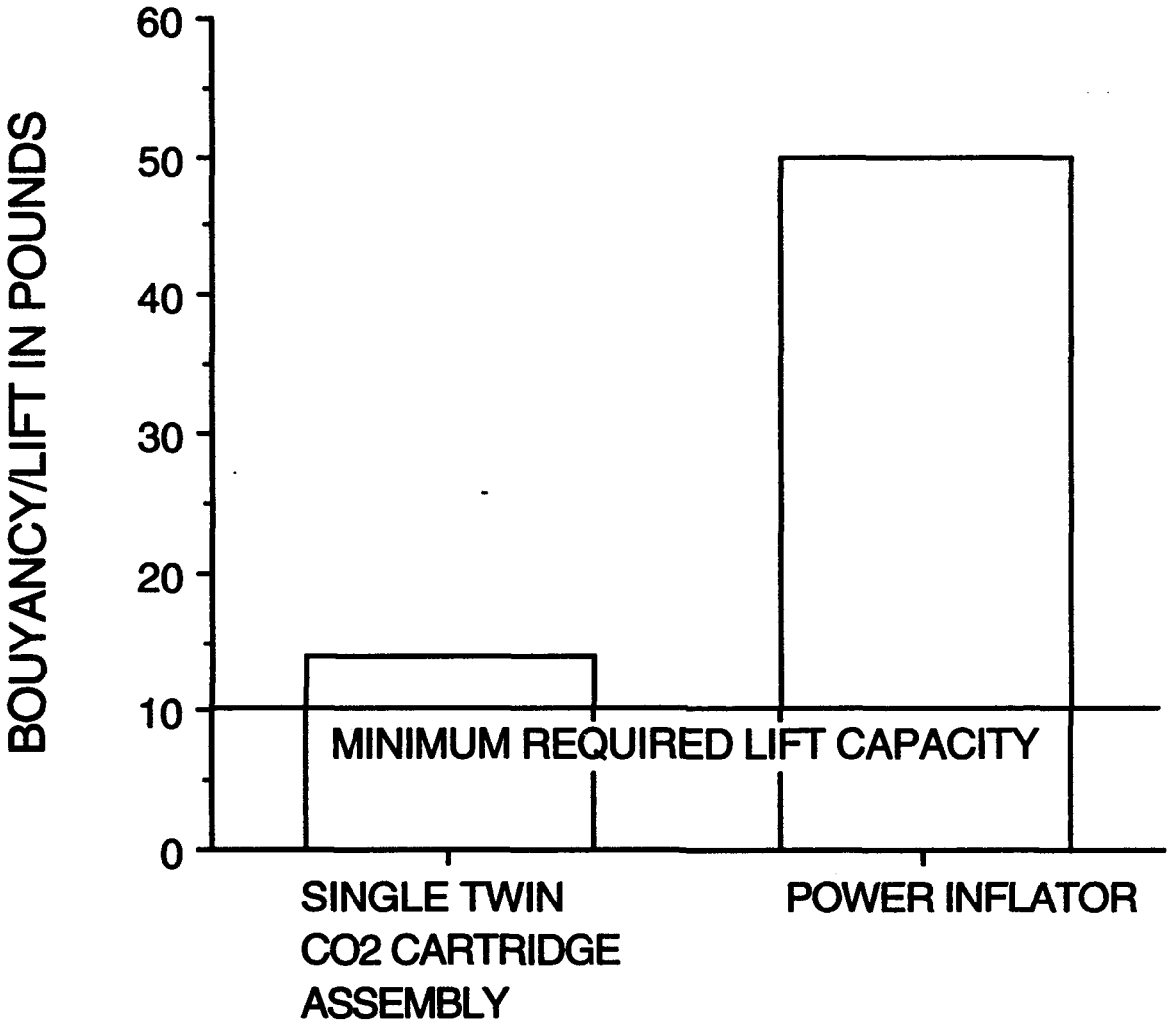

Figure 1. Lift Capacity at 18.30 msw (60 fsw)

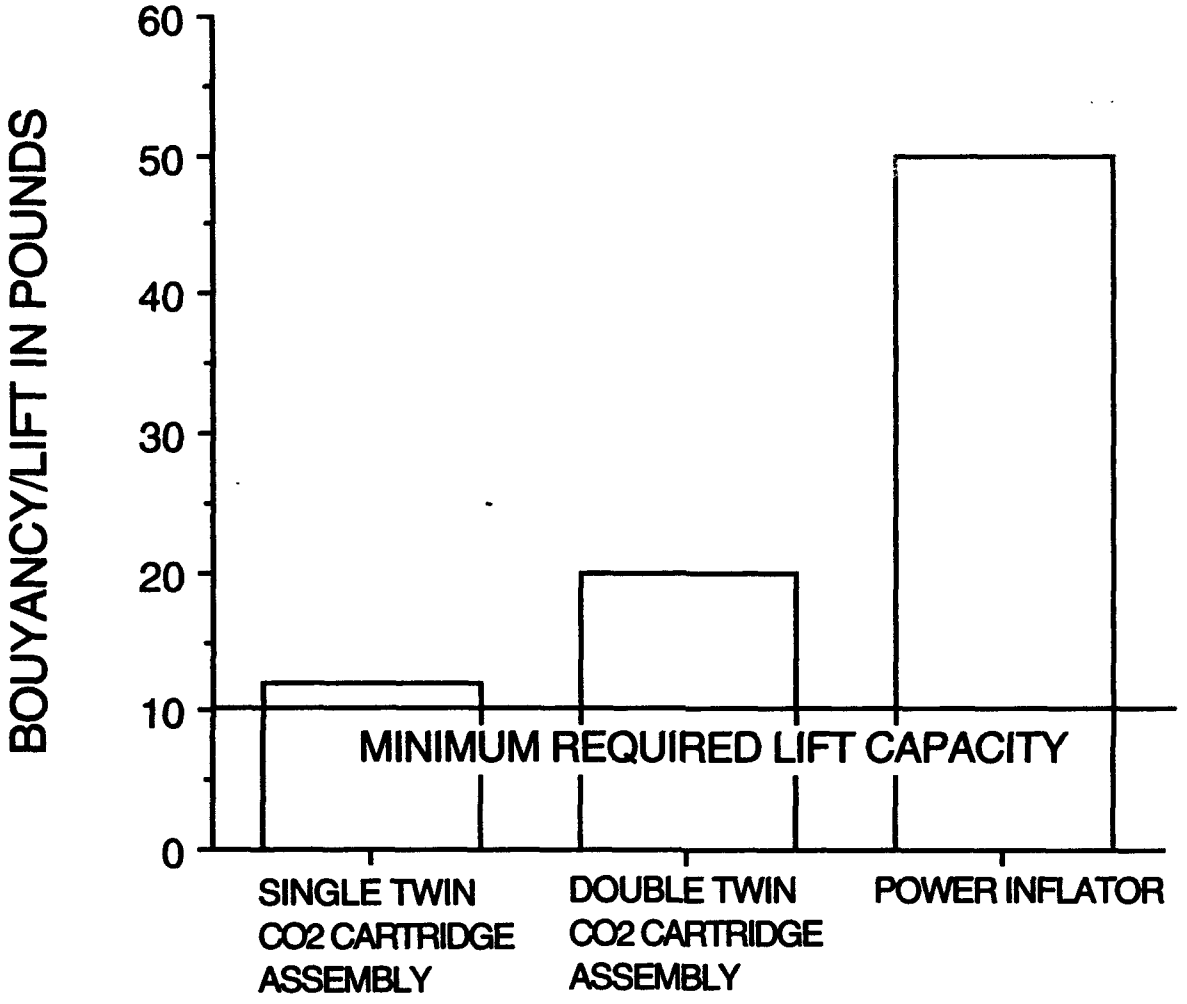

Figure 2. Lift Capacity at 39.62 msw (130 fsw)

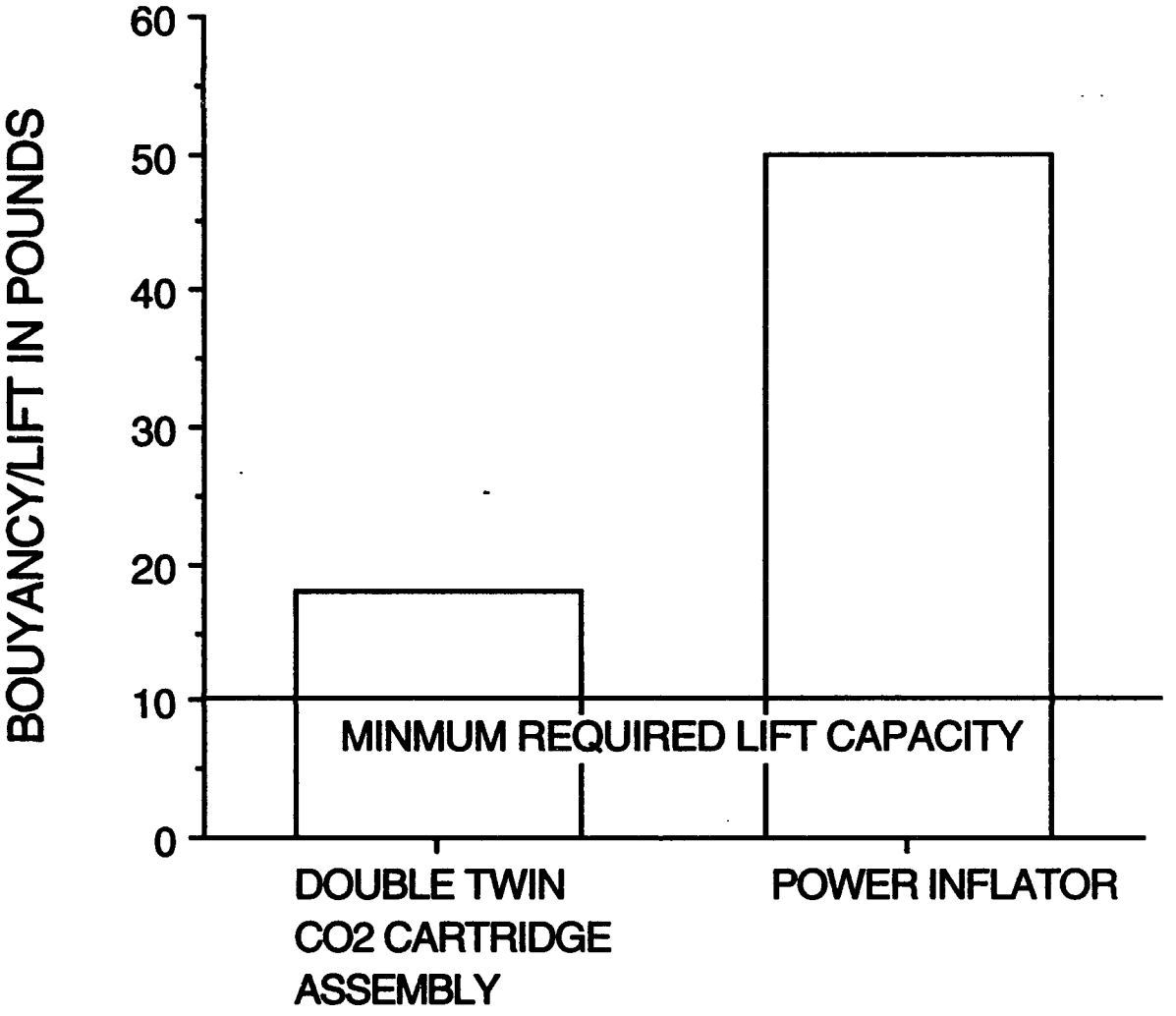

Figure 3. Lift Capacity at 58 msw (190 fsw)

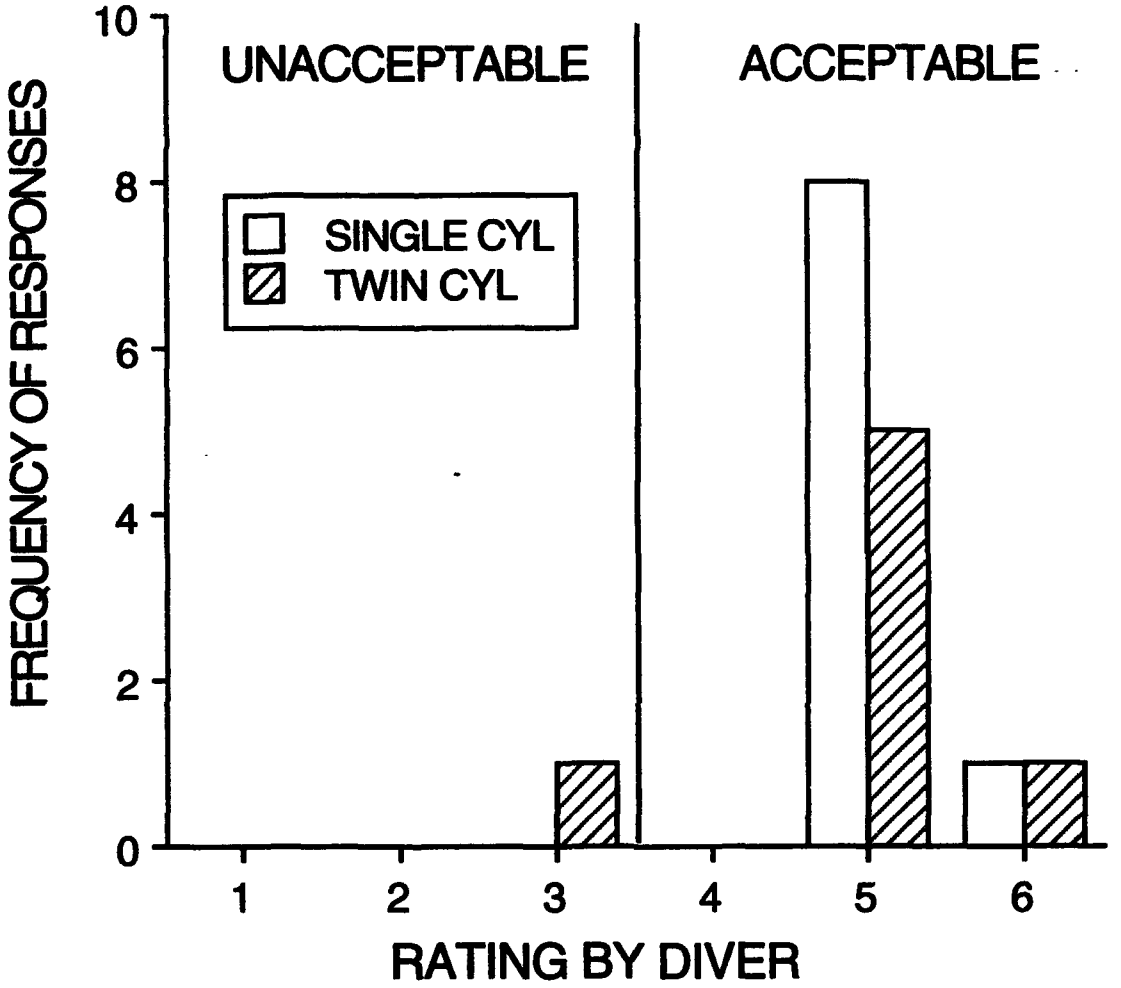

Figure 4. Overall Comfort

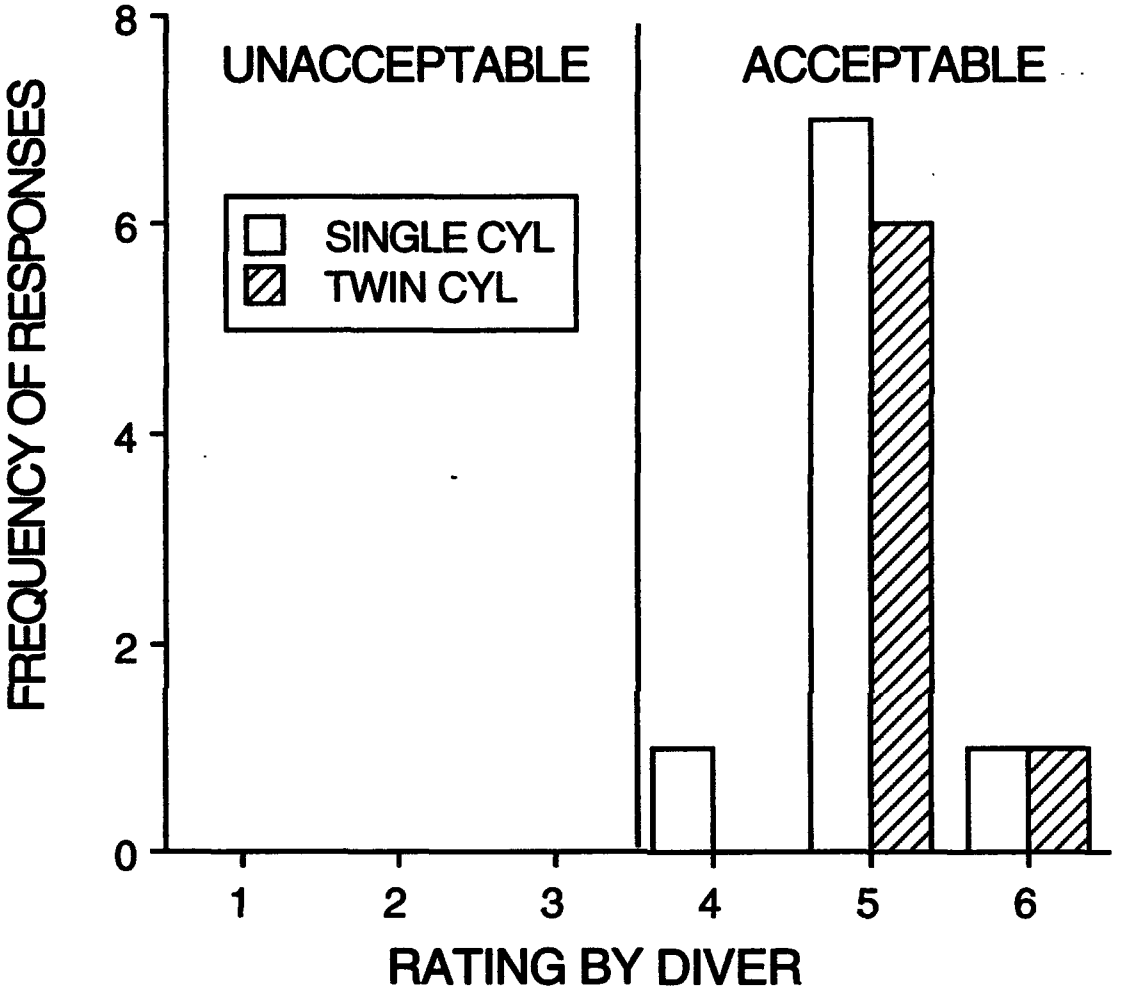

Figure 5. Mobility With B. C.

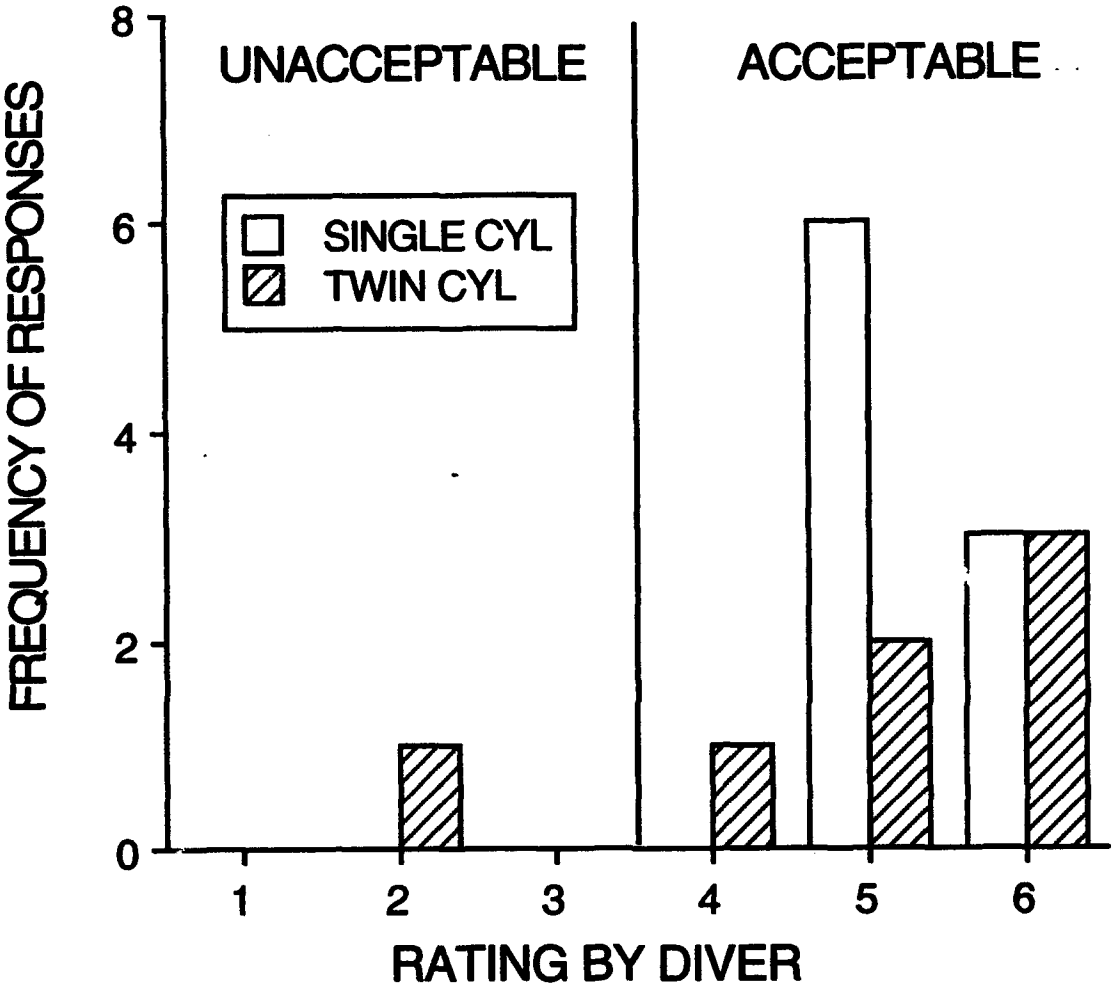

Figure 6. Donning and Doffing

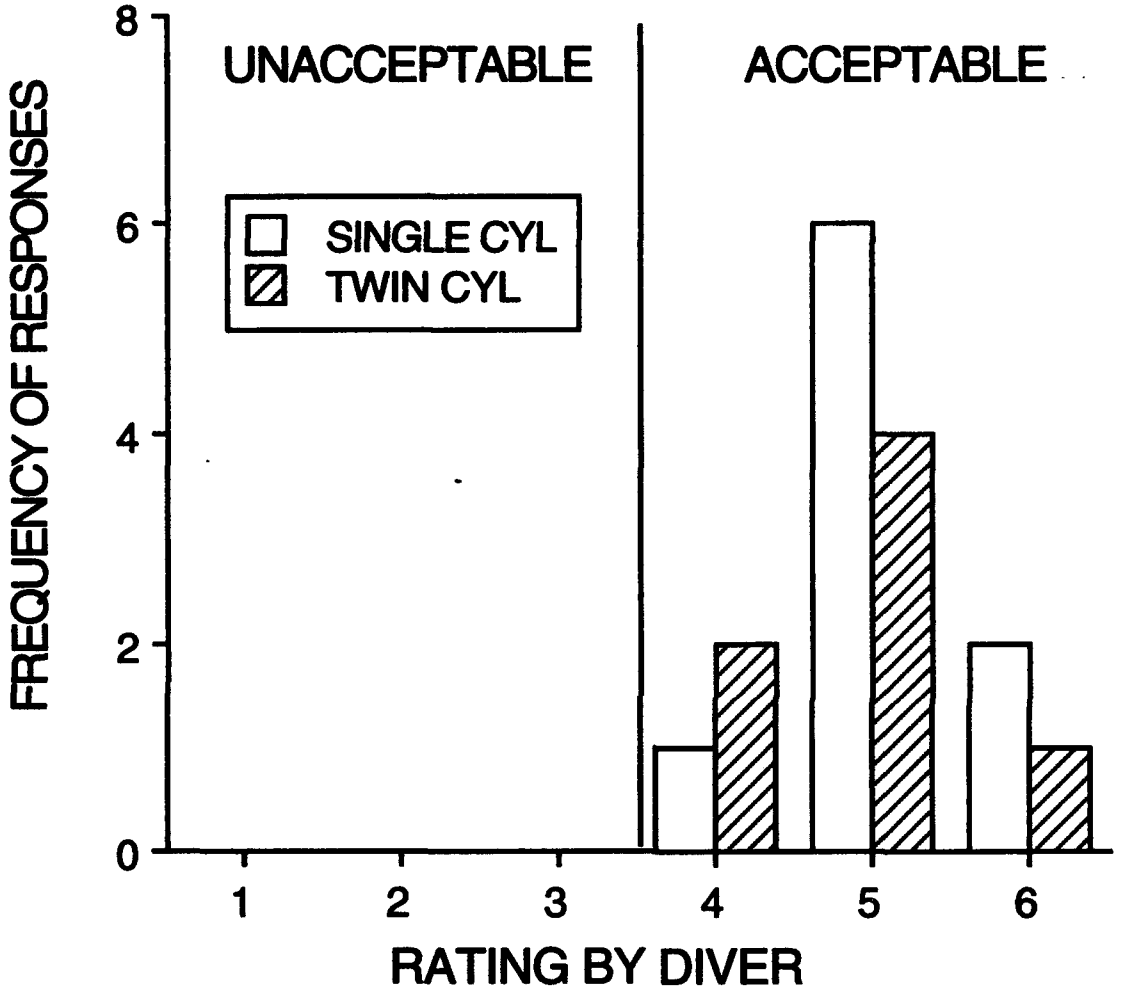

Figure 7. Ease of Attaining Neutral Bouyancy

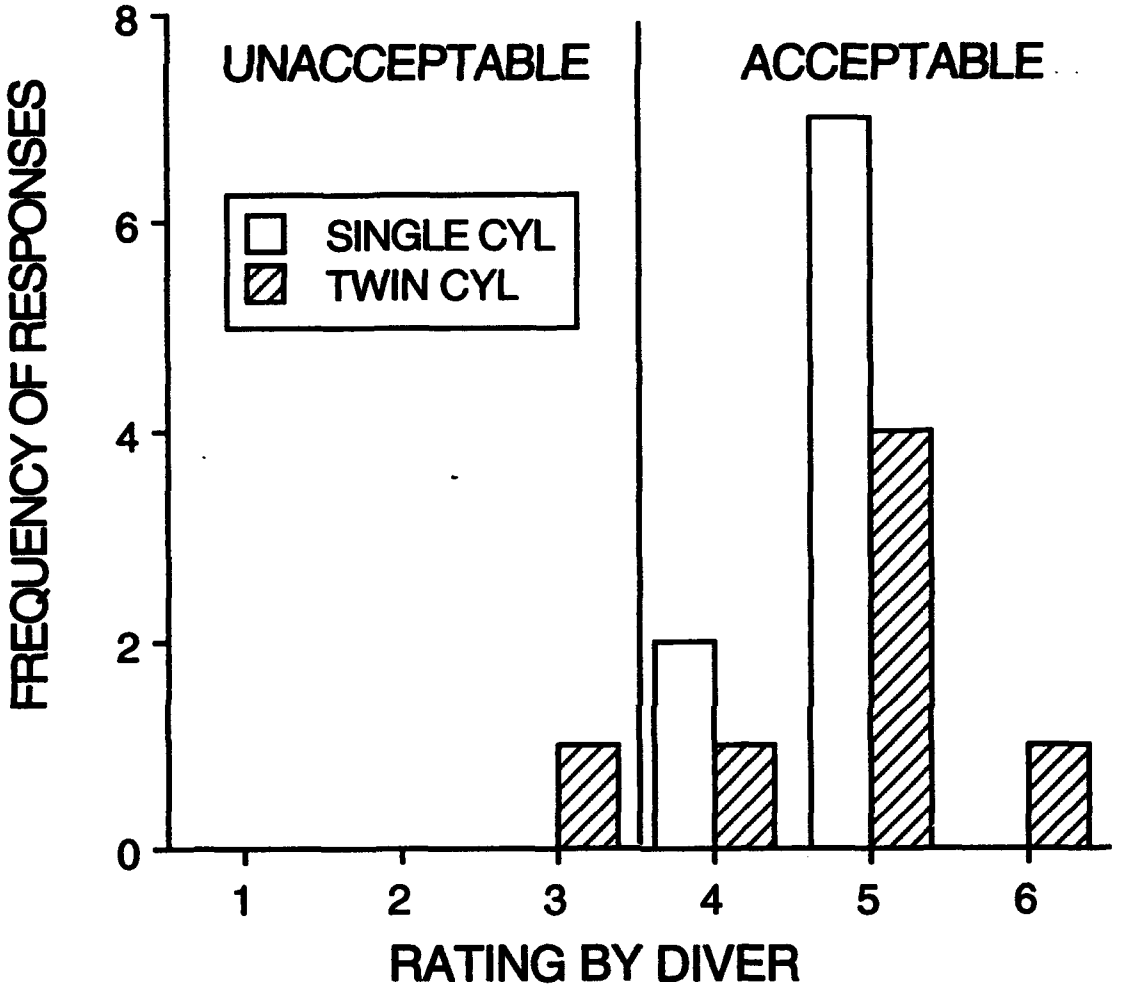

Figure 8. Location of Operating Controls

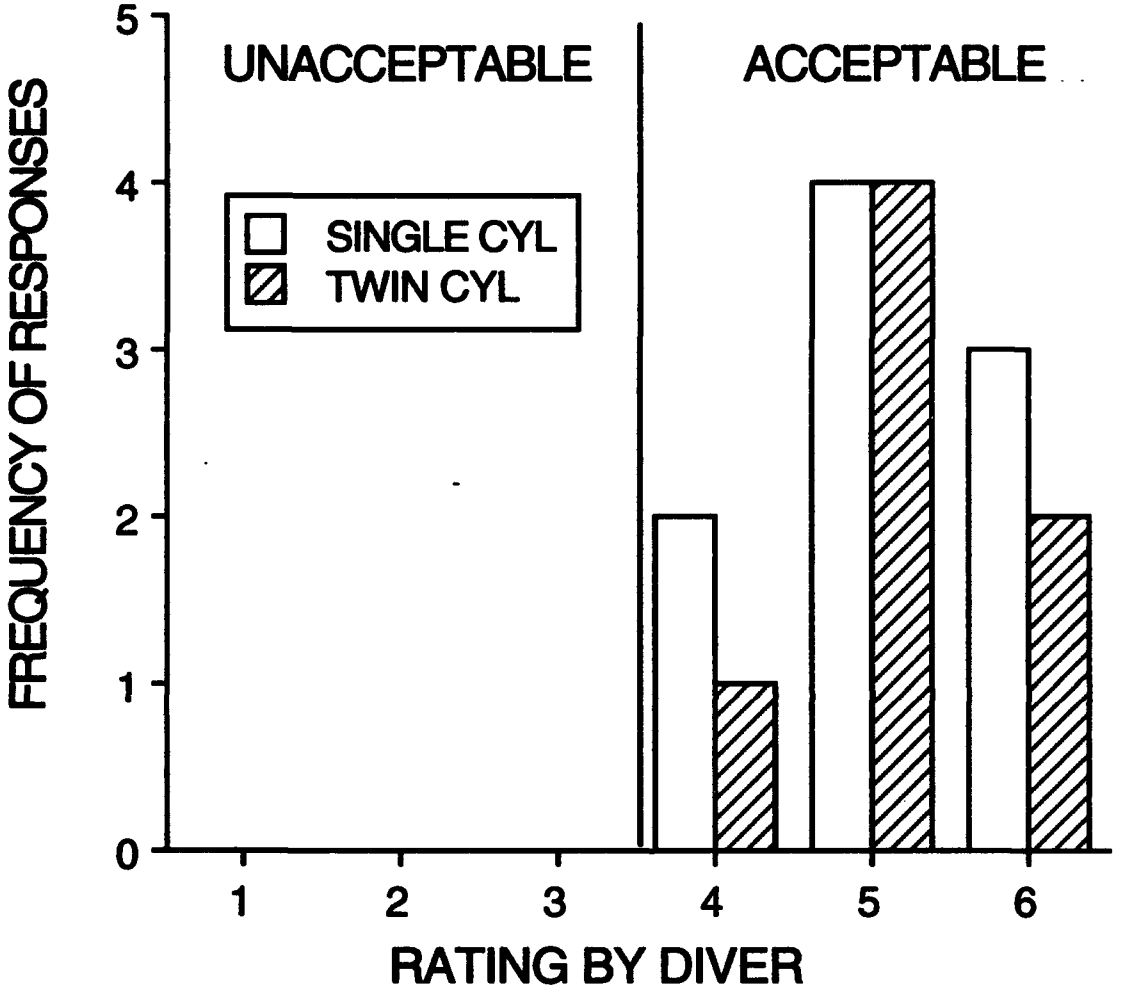

Figure 9. Ease of Operation

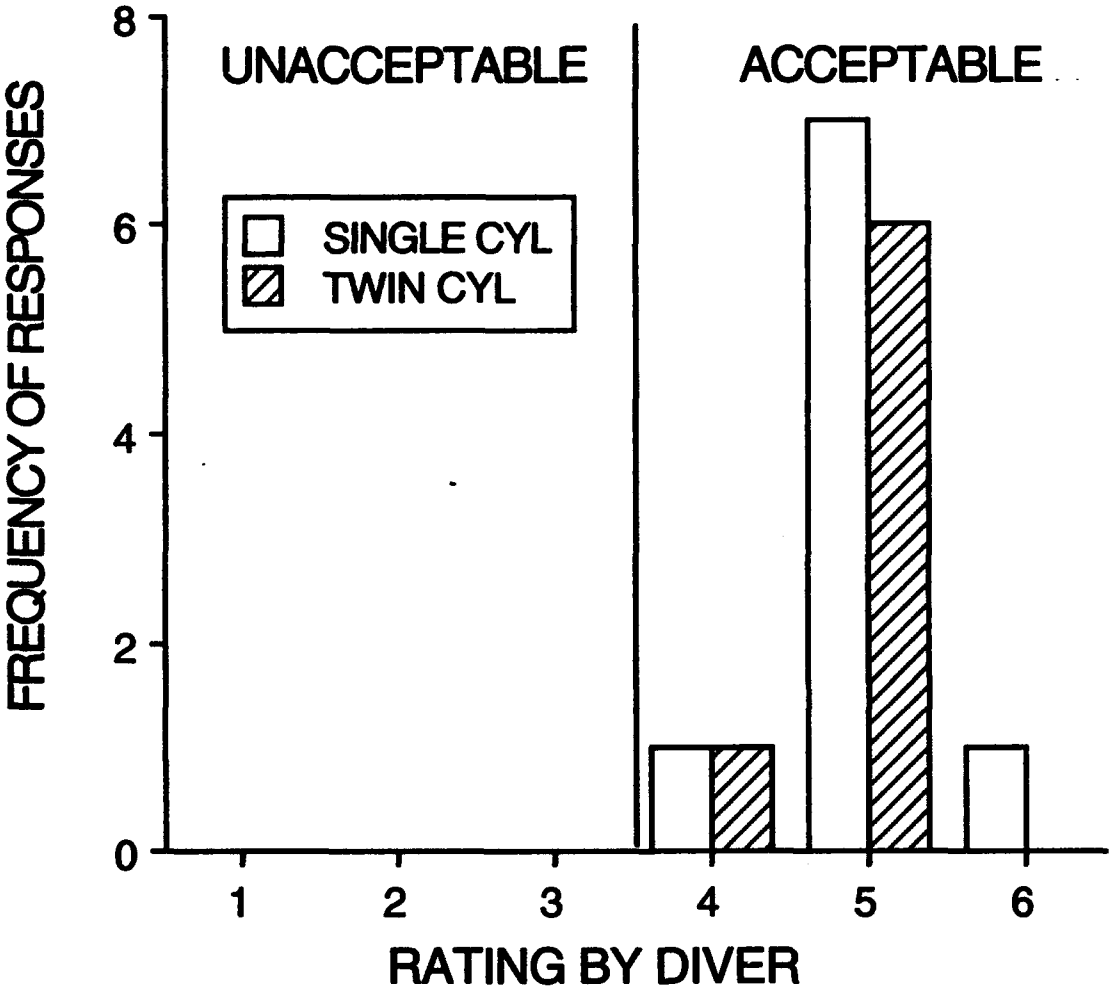

Figure 10. Overall Rating

APPENDIX A

MANNED DIVING EVALUATION QUESTIONNAIRE FOR BUOYANCY COMPENSATORS (BC) AND LIFE PRESERVERS (LP)

INSTRUCTIONS: Please complete this questionnaire carefully for each dive that you do during the period of the evaluations. The type of buoyancy compensator eventually chosen for use by the USN may depend on your answers. A new questionnaire must be completed for each dive.

Check the appropriate answer to each question or fill in the blank spaces provided and then add any relevant comments that you may have.

1. Make/model of BC/LP:_____

2. Serial number of BC/LP:_____

3. Name of diver:_____ Date:_____

4. Dive profile: Depth:_____ Time:_____

5. Brief description of dive:_____

_____

6. How many previous dives with this BC/LP?_____

7. BC/LP rating system

1. Extremely Poor	4. Adequate
2. Poor	5. Good
3. Not Quite Adequate	6. Excellent

8. How would you rate the comfort of the BC/LP?_____

   Comments:_____

9. How would you rate your mobility while using this BC/LP?_____

   Comments:_____

10. How would you rate the ease of donning and doffing this BC/LP?_____

    Comments:_____

11. How would you rate the ease of attaining neutral buoyancy with this BC/LP?_____

    Comments:_____

12. How would you rate the location of the operating controls found on this BC/LP?_____

Comments:_____

13. How would you rate the ease of operating the inflation/deflation controls found on this BC/LP?_____

Comments:_____

14. Did you experience water drag with the BC/LP while free swimming?_____

Comments:_____

15. Did you feel comfortable diving with this BC/LP?_____

Comments:_____

16. How would you rate this BC/LP?_____

Comments:_____

17. Please make any additional comments about the BC/LP you think should be made known._____

_____

_____

_____

_____